# Technology for the United States Navy and Marine Corps, 2000-2035

## Becoming a 21st-Century Force

VOLUME 8 Logistics

NAVAL STUDIES BOARD
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# Technology for the United States Navy and Marine Corps, 2000-2035

## Becoming a 21st-Century Force

### VOLUME 8 Logistics

Panel on Logistics
Committee on Technology for Future Naval Forces
Naval Studies Board
Commission on Physical Sciences, Mathematics, and Applications
National Research Council

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# Preface

This report is part of the nine-volume series entitled *Technology for the United States Navy and Marine Corps: Becoming a 21st-Century Force.* The series is the product of an 18-month study requested by the Chief of Naval Operations. To carry out this study, eight technical panels were organized under the Committee on Technology for Future Naval Forces to examine all of the specific technical areas called out in the terms of reference.

On November 28, 1995, the Chief of Naval Operations (CNO) requested that the National Research Council initiate (through its Naval Studies Board) a thorough examination of the impact of advancing technology on the form and capability of the naval forces to the year 2035. The terms of reference of the study specifically asked for an identification of "present and emerging technologies that relate to the full breadth of Navy and Marine Corps mission capabilities . . . ." The CNO's letter of request with the full terms of reference is given in Appendix A of this report.

Logistics was not called out explicitly in the CNO's letter of request. However, the events of the Gulf War demonstrated, and the Navy and Marine Corps leadership recognized at the commencement of the study, that logistics will play an increasingly important role in future naval operations. Its importance was also recognized in a previous Naval Studies Board report, *The Navy and Marine Corps in Regional Conflict in the 21st Century* (National Academy Press, Washington, D.C., 1996). Accordingly, the Panel on Logistics was constituted to address the application of technology to logistical support of maritime and littoral operations.

The panel membership included expertise not only in standard logistic analysis, but also in military operations analysis, engineering and systems design, naval architecture and ship design, modeling and simulation, naval operations, information systems, industrial management, communications and electronics, command and control, and naval aviation.

To carry out its task, the panel met eight times to receive briefings from Service and industry representatives, visit facilities, deliberate, and draft its report. The many contributors to these discussions are acknowledged in Appendix B. In addition, the panel participated in the three plenary meetings for the overall study. The first, in March 1996, was addressed by the Chief of Naval Operations and many high-level officials of the Navy Department, the other Services, the Defense Department, and industry. This served as an organization meeting and conveyed a common, starting information base to the entire study membership. At the second plenary session, in October 1996, all the members of the study had their first opportunity to review each other's work, to see how the results of the work of all the eight panels were coming together into an integrated message, and to feed the results back into their own efforts. The third plenary session, in March 1997, served as a coordination and writing session in which all of the panels' reports and the overview report were completed for final review. The chair and vice chair of the Panel on Logistics also participated in bimonthly meetings of the Committee on Technology for Future Naval Forces. These meetings served to inform the panel chairs and study leadership of progress in the various panels' efforts and to resolve issues that cut across the responsibilities of more than one panel. The meetings also helped to ensure that common attention was paid to the relationships of the diverse panel outputs to each other and the significance of those outputs for the naval forces.

This report by the Panel on Logistics emphasizes the significance of and critical dependence on logistics for future naval forces and points toward a direction for applying technology to help achieve efficient and effective support of naval operations in the future. The panel concentrated on logistical support of forward-deployed naval forces, both those at sea and those ashore, and on maintaining weapon system readiness.

# Contents

# Executive Summary

## TECHNOLOGY FOR LOGISTICAL SUPPORT OF FUTURE NAVAL FORCES

The Navy and Marine Corps have started transforming their logistic operations to accommodate a new national security environment and new needs of naval operations. It is, by and large, a management task: changing the way logistic functions are accomplished, and revising traditions, cultures, and organizational prerogatives that have served naval logistics well for many years. This is tantamount to reengineering the logistic system. However, as one looks to the future, technology will play an essential role in enabling the desired changes. Technology will help make feasible the new logistic capabilities needed to support future warfighting concepts and the type of efficient, responsive logistic system that naval forces will demand. The topic of this report is the application of technologies for logistical support of future naval forces over the next several decades. The panel assumes an operational context for logistics: supporting naval force operations in an overseas littoral area. The panel concentrates on the most fundamental of logistic processes, the activities on which the Navy spends 30 percent of its budget ($22 billion in 1995):[1]

- The management and movement of materiel in support of U.S. naval forces at sea, from the sea, and over the shore; and

[1]This estimate includes only supply, maintenance, and transportation activities. It does not include medical services, construction, facilities maintenance, and a variety of other support services sometimes categorized as "logistics."

• The design and maintenance of weapon systems so as to maximize their operational readiness.

## MANAGING AND MOVING MATERIEL

The ability of naval forces to deploy and remain on station in international waters—and to maneuver, engage, and redeploy quickly across the sea-land interface—makes them a versatile military force in littoral areas. This variety of naval operations generates several very different types of logistic activity that, while sharing the common goals of managing and moving materiel, do so under different operating conditions. Different capabilities and different technologies are needed to be effective. The panel discusses the technology needed to manage and move materiel in three areas: (1) supporting naval forces at sea, (2) supporting the evolving Marine Corps concept of Operational Maneuver From the Sea, and (3) conducting logistics-over-the-shore operations.

• *Supporting naval forces at sea.* The Navy's under-way replenishment methods, though efficient in moving materiel from the logistic ship to a combatant, may leave the combatant with supplies hastily stowed, sometimes requiring "all hands" working parties and several days before they can be stored properly, locations can be recorded, and most importantly, the stores can be issued.

Information and packaging technology should soon be available to enable resupply points and logistic ships to know enough about the configuration of each ship, the ship's storerooms, strikedown routes (from the deck, where materiel is received, through hatches and passageways to storerooms), and locations of materiel on board to permit packaging, labeling, and sequencing of deliveries for efficient strikedown and storage. New technology will make it possible to deliver supplies to combatants in "warfighter-ready" status, just as commercial retail firms are delivering merchandise "shelf ready" or "rack ready."

Replenishing vertical-launched missiles at sea is difficult, slow, and dangerous even in calm seas. It is nearly impossible under less benign conditions. While the Navy is working on improving this capability, finding and installing more efficient means of rapidly rearming and loading missile launchers at sea must be pursued.

Further, the combat logistic ships that currently shuttle supplies to ships at sea are nearing the end of their operational lives. The time is opportune to perform a systematic, comprehensive assessment of the process of supporting ships at sea, including the role that containers can play in efficient storage, handling, and movement of materiel. Based on such an assessment it will be possible to design not just the next generation of shuttle ships, but also the at-sea logistic system of the future—the way supplies are stored, packaged, labeled, tracked, and handled on board both logistic ships and combatants.

• *Supporting Operational Maneuver From the Sea.* Under the new concept of Operational Maneuver From the Sea, the Marine Corps will seek to provide

from ships 25 or more miles offshore much of the logistic support traditionally provided from the beach support area. To succeed with a substantially sized force, the Navy and Marine Corps will need to develop new capabilities in logistic command, control, and communications; sea-basing of platforms; and ship-to-unit transport of supplies.

To meet mission requirements while presenting as small a logistic footprint ashore as possible, logistic operations will have to be rapidly planned, tightly controlled, and precise in delivering the necessary support when and where it is needed. Command and control of logistic operations will depend on applying technologies for automatic identification and tracking of shipments; for monitoring truck and materiel-handling equipment performance; and for automatically reporting supported units' expenditures of ammunition, fuel, and supplies. It will also require creating the analytic tools—models, simulations, and algorithms—needed to use effectively the vast amounts of available data for early recognition and anticipation of logistic requirements; for identification, assessment, and selection of alternative courses of action; and for monitoring of the status, progress, and performance of logistic operations. All will depend on long-range, secure, assured communication of a steady stream of digital data updating files on unit locations, supply status, equipment performance, parts availability and shipments, and the myriad of other details needed to coordinate logistic activities. Logistics will require the same high priority for communications traditionally reserved for operations and intelligence traffic.

If logistics is to be sea-based, the Navy and Marine Corps will need the capability to perform at sea, in large enough volumes, the equipment maintenance and materiel distribution functions now performed ashore. The panel believes that either a new-design, dual-role amphibious warfare ship or a ship designed specifically to support sea-basing operations will be needed.

Under Operational Maneuver From the Sea, the distances between deployed units and their sea base of logistic support could well exceed the capabilities of existing transport. With units well inland, much of the logistic operation will depend on air transport. The heavy-lift helicopter will be the workhorse, and the current helicopter, the CH-53, will have to be upgraded to increase its range at maximum load. Precision airdrop and unmanned aerial vehicles could complement vertical-lift capabilities. Eventually, a new-design, very-short-takeoff-and-landing, tactical transport is likely to be needed to span the distances that modern warfare creates between logistic bases and maneuvering combat units. The ship-to-beach transport burden will fall on the air-cushion vehicles, which, although very capable, are expensive to operate and somewhat fragile. A relatively inexpensive, high-speed, rugged lighter would be a valuable complement.

- *Conducting logistics-over-the-shore operations.* Although the most challenging task will be to support amphibious operations, most sea-to-land logistic operations are likely to occur under relatively benign conditions, without strong enemy opposition. When possible, offloading will take place at established ports,

using commercial port facilities. When such facilities are unavailable or inadequate, ships will be unloaded onto lighters or rapidly assembled causeways for movement of cargo ashore. Today, such "logistics-over-the-shore" operations are severely limited by adverse weather conditions. Rough seas (sea state 3 and higher) bring these operations to a halt. Because calmer conditions exist only about half the time in many areas of the world where military operations are most likely, developing the capability to conduct logistics-over-the-shore operations in rough seas is essential. The Navy and Marine Corps should give high priority to developing the stabilized cranes, lighterage, improved causeway systems, roll-on and roll-off discharge facilities, and portable ports needed for such operations.

## MAINTAINING WEAPON SYSTEM READINESS

Maintaining the readiness of weapon systems—ships, airplanes, trucks, howitzers, and other equipment—is a major activity of naval forces, employing 47 percent of the Navy's active-duty sailors and 24 percent of active-duty marines. Reducing the maintenance needed and the learning required to perform that maintenance more effectively and efficiently could have substantial payoff in freeing up personnel and budgets for other needs. Information technology holds the promise of changing fundamentally the way readiness is maintained and reducing resource requirements. It will do so by providing all participants in the process of producing and supporting a weapon system the knowledge to make "best" decisions throughout its life cycle. Pulling together the many applications of information technology focused on weapon system readiness will be the key to exploiting the capabilities these systems offer.

During weapon system design, the use of computer-based digital databases and simulation will enable design engineers and logisticians to assess the reliability and maintainability features of a design, identify any design-induced logistic problem early, and feed it back to design engineers for correction. This is the point of greatest leverage in maintaining readiness because there is no substitute for designing high reliability into a weapon system. Logisticians will be able to design and develop logistic and training packages concurrently with weapon design, improving the match between weapon system and support. Digital databases will permit the establishment of sound configuration management—the foundation of effective logistic support—throughout a weapon system's life. Computer-based training will permit reducing the time required for technical training, improve skill retention, and move some training out of the classroom to job duty stations.

The combination of embedded sensors, digitization of technical data, worldwide telecommunications, and intelligent software will make available to the maintenance technician, on a portable digital display, up-to-date and accurate status, diagnostic, and repair information. This "interactive electronic technical manual" will be tied electronically to the supply system so that correct parts can

be identified, ordered, and provided from the most readily available sources, all without the need for error-prone, manual input of data. Tests indicate that such an Integrated Maintenance Information System (IMIS) can reduce maintenance time, maintenance errors, and parts use and can enhance success in performing maintenance tasks.

Real-time information, rapid transportation, and rapid manufacturing will help reduce today's large inventories at operational sites. Assured, secure worldwide communication of logistic information will enable total visibility and efficient use of assets. Real-time tracking of shipments will permit anticipation of parts arrivals, detection of delays or misshipments, and adjustment of priorities.

## CONCLUSIONS

Logistics, on the scale required to support naval forces in a littoral region halfway around the world, is an immensely complex, difficult undertaking, performed always under trying and often hostile conditions. The conditions of the future promise to be no less challenging, and in some respect perhaps more so, than those of the past. Only responsive, focused logistic activity will enable the conduct of military operations within the action time lines needed for mission success. Meeting these high expectations in the future will require new logistic capabilities and new ways of accomplishing logistic tasks. Technology will play essential roles in both.

Information technology is likely to offer the greatest leverage in creating the logistic system of the future. It will offer logisticians at every operational level the data to anticipate or respond to logistic needs, to assess and select best courses of action, to make the best use of logistic assets, and to control the flow of logistic support. The panel highlights three areas in particular that it believes can benefit substantially from the use of information technology: (1) planning and controlling the flow of supplies to naval forces at sea, from the sea, and over the shore; (2) providing the logistic command, control, and communications needed to support Operational Maneuver From the Sea; and (3) maintaining weapon system readiness.

Advances in handling and transport of materiel also will be necessary to support the type of military operations expected in the future. The major new capabilities that technology must provide are rearming missile launchers at sea; providing a sea-based support platform, low-cost, high-speed water craft, and air transport to support the evolving Marine Corps concept of Operational Maneuver From the Sea; and conducting logistics-over-the-shore operations in rough seas. Advances also will be needed to fully exploit the advantages of containers in moving and managing materiel.

The full benefit from technology, however, will be gained only by applying it in the context of logistic enterprise processes that draw together, in an integrated and deliberate design, all relevant activities to accomplish specific goals.

Technology, particularly information technology, will enable logistic processes that differ substantially from the traditional ones. Rethinking how logistic functions should be accomplished, designing enterprise processes that will be feasible in the future, and charting paths to the creation of these new processes will be the keys to exploiting technology. In short, the Navy and Marine Corps should use new technology to change the way logistics is accomplished, not simply to perform current tasks better.

Several new logistic ships will be needed in the next decade or so—replacements for aging shuttle ships for ammunition and stores, replacements for the maritime prepositioning ships whose lease is expiring, and possibly a new sea-based support ship to sustain Marine Corps operations from the sea. These new ships will represent major, long-term investments in logistic capability. Their designs should be integral parts of the logistic processes they will support during the next 30 to 40 years. This is an opportune time to examine and design the logistic processes of the future.

## RECOMMENDATIONS

1. The Navy and Marine Corps should take the opportunity now, before starting the design of new logistic ships, to define and design future logistic processes, from the sources of materiel to its delivery in warfighter-ready condition to naval forces at sea, from the sea, and over the shore. Once the logistic processes are designed and the roles of logistic ships have been decided, the Navy should examine the desired characteristics of new logistic ships to see if they can be met by a common design, a modular design, or a design that is convertible to alternate roles.

2. The Navy and Marine Corps should learn how to exploit the advantages of standard shipping containers in supporting naval forces at sea, from the sea, and over the shore. Containers offer efficiency, control, and security in transporting and handling materiel. With emerging technology for load planning, content tagging, and shipment tracking, containers can be transformed from dumps of randomly stowed materiel to virtual supply depots of immediately accessible materiel that is warfighter ready.

3. The Navy and Marine Corps should develop and apply to logistic operations the emerging information technologies that promise to enable management of processes as integrated enterprises supporting naval operations:

- Automated marking and identification technology to eliminate manual input of critical logistic data;
- Sensors and intelligent software for monitoring logistic activities (e.g., shipments and maintenance) and for carrying out routine actions automatically;
- Displays and software for assimilating, presenting, and making easier to use the vast quantities of data;

• Modeling and simulation, for real-time planning, assessment, and selection of courses of action; and

• Distributed collaborative planning, for rapid coordination of resupply actions among the supplier, the transporter, and the user.

4. The Navy and Marine Corps should formulate and commit to a long-term plan—a path of evolution—to guide technology development, investment, and fleet implementation of a standard integrated, information-based process for maintaining weapon system readiness. The process should encompass the entire life cycle of a weapon system, from acquisition to disposal. The plan should give particular attention to current weapon systems, to infrastructure and common support needs, to integration of industry capabilities into the process, and to developing and exploiting the capabilities of the following technologies:

• Integrated digital weapon system databases;

• Computer-based technical training;

• Integrated maintenance information systems that tie together information relevant to a technician's task and present it at the point of use in the most usable form;

• Sensor-based diagnostic and prognostic software; and

• Automated identification, tracking, and control of parts, supplies, and shipments.

# 1

# Introduction

Naval logistics is a worldwide endeavor, stretching from the factories, shipyards, depots, and naval bases in the United States to advanced bases overseas and to the ships and Marine Corps units deployed in the oceans and seas around the globe. Whether naval forces are fighting a war, providing humanitarian relief, evacuating U.S. citizens, or performing any of the many roles they serve, logistics provides the equipment, supplies, and support services necessary to ready them for their missions and sustain their operations.

Two events of the 1990s changed the views of future naval logistic needs: (1) the disintegration of the Soviet Union and (2) the Persian Gulf War. With the Soviet Navy no longer a major threat, greater emphasis was placed on supporting Navy-Marine Corps task forces operating in the world's littoral regions, often as part of joint operations with other U.S. military services or in combined operations with other nations' militaries. Events also prompted reductions in the size of the Navy—in the number of ships and aircraft that need support, the number of ships and aircraft available to provide support, and the number of overseas bases.

The Persian Gulf War reinforced the need for rapid military response to regional events and to the threats that regional powers could pose to U.S. naval forces in littoral areas. Especially, it drew attention to the vulnerability of traditional logistic operations to enemy action. The slow buildup of forces, deliberate development of a robust theater infrastructure, and laying in of large stocks of supplies that characterized U.S. military operations in the past would not meet the needs of the future. The war made clear that logistics had to become more adaptive and more responsive—better able to provide timely support to operating forces—while presenting less of a presence in the theater of operations.

As these events were shaping views of future logistical needs of naval forces, substantial reductions in Navy Department budgets drew attention to the costs of support activities, including logistics. The Navy has been spending at least 30 percent of its budget on logistics ($22 billion in 1995, for instance).[1] Many are convinced that this share is disproportionately high, that it needs to be reduced to free funds for other tasks and needs, and further, that the success of some U.S. business firms in reducing the cost of logistics provides evidence that more efficient naval logistics is possible. Thus the challenge is to create a logistic system that is more effective in providing timely support to naval forces, places fewer logistic activities at risk in a war zone, and costs less in the long run.

The Navy and Marine Corps have started transforming their logistic operations to accommodate the new environment and to meet the new needs of naval operations. This is, by and large, a management task—changing the way logistic functions are accomplished and revising procedures and organizational prerogatives that have served naval logistics well for many years. Technology will play an essential role in enabling the desired changes; it will help make feasible the new logistic capabilities needed to support future warfighting concepts and the type of efficient, responsive logistic system that naval forces will demand. Applying technology to logistical support of future naval forces is the panel's topic. The time horizon is mid to long term, 10 to 30 years.

This report assumes an operational context for logistics—supporting naval force operations in an overseas littoral region. By doing so, it sets aside a host of issues related to the continental United States (CONUS) logistic activities and to the management of logistic processes that are concentrated primarily in the United States. For example, the report does not deal with the shipyards, base closures, port access, outsourcing, industrial base, or any of a myriad of similar management and policy issues that occupy senior logisticians today. Instead, the focus is on the logistics of supporting forward-deployed naval forces—both ships and aircraft at sea and ground forces as they project U.S. military power ashore.

The technologies of primary interest are those underlying most logistic tasks—information, materiel handling, and transport. Yet, although the specific logistic technology needs of future forces are identified, the recurring theme is that simply applying new technology to current ways of accomplishing logistic functions is insufficient. To exploit fully the capabilities offered by these technologies will require that logistic processes be redesigned—the way in which the Navy and Marine Corps think about logistics, about its purposes, and about how it is planned, conducted, and managed. This bringing together of very-large-

[1]This estimate includes only supply, maintenance, and transportation activities. It does not include medical services, construction, facilities maintenance, and a variety of other support services sometimes categorized as "logistic."

scale, complex systems—often systems of systems—is in itself a technology, one in which U.S. industry and the U.S. military traditionally have excelled. When conducted on the scale required to support naval forces, logistics is the type of very large, complex undertaking that, to be successful, must be viewed as a set of enterprise processes. This report concentrates on the two most fundamental of logistic processes: (1) managing and moving materiel and (2) maintaining weapon system readiness.

# 2

# Managing and Moving Materiel

The ability of naval forces to deploy and remain on station in international waters and to maneuver, engage, and redeploy quickly across the sea-land interface makes them a versatile military force in littoral areas. The variety of operations generates several very different types of naval logistic activity.

Figure 2.1 depicts the major naval logistic activities in a littoral area. Arrows at the top left portion of the figure represent the under-way replenishment of ships at sea. Although ships deploy with sufficient fuel, ammunition, and stores on board to permit them to operate independently for a long time, the duration of ship deployments, even in peacetime, usually exceeds substantially a ship's ability to operate without resupply. In combat, frequent resupply—every two or three days—is a necessity. For example, a carrier battle group may use as much as 12,000 barrels of aviation and ship fuel, 150 tons of ordnance, and 30 tons of stores in one day when conducting surge operations.

To deliver the materiel to the fleet, the Navy moves fuel, ammunition, and other supplies in bulk, usually by commercial surface carriers, to overseas locations where they are broken out and positioned for forward support of the fleet. Fleet-operated combat logistic force ships (oilers, ammunition ships, and stores ships) then shuttle supplies from the resupply points either to the battle forces directly or to station ships (multiproduct, fast combat support ships) that accompany the battle groups. Under-way transfer of materiel from a logistic ship to a combatant is either by traditional high-line transfer between the two ships steaming side by side (connected replenishment) or by helicopter (vertical replenishment). Most replacement personnel, spare parts, and small items coming from CONUS move by air to overseas points and from there to ships during port visits

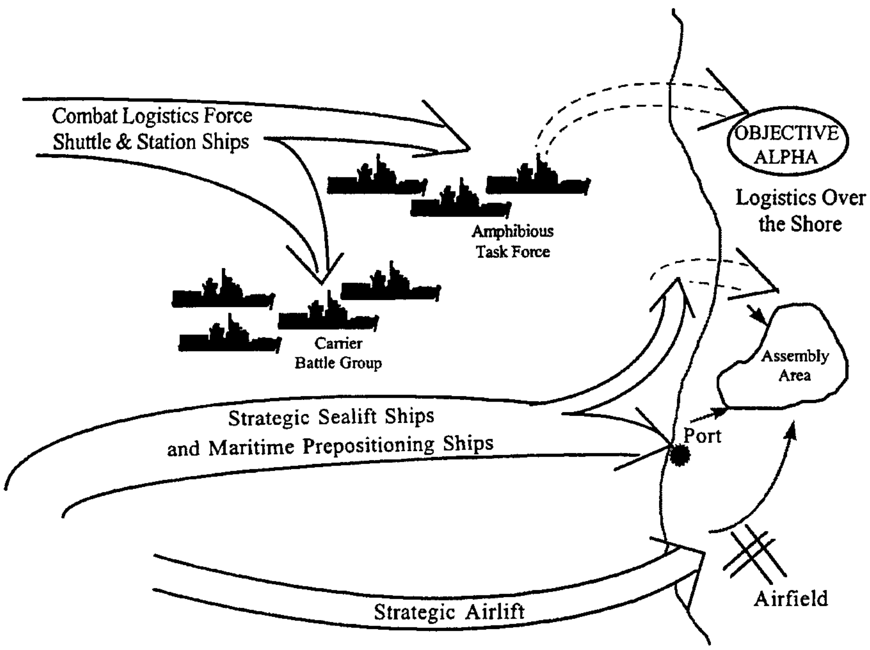


FIGURE 2.1 Naval logistic activity.

or to the battle group either by carrier on-board delivery (COD) aircraft or by helicopter.

In Figure 2.1, the dashed arrows between the amphibious ships and the land objective represent an amphibious assault by a Marine Corps air-ground task force. The traditional mode of amphibious operations has been to disembark the assault echelon close to shore (within 3 or 4 miles), establish a beachhead, secure the area to a distance of about 30 miles to protect it from enemy direct and indirect fire, build up a logistic support base, and then push out to other objectives. The Marine Corps concept for future amphibious operations, Operational Maneuver From the Sea, seeks to obviate the initial buildup of a beach support area by launching the assault from well over the horizon (25 miles or more), seizing initial objectives well inland (perhaps 50 to 100 miles), and providing from ships at sea much of the combat support and combat service support traditionally provided from the beach support area—command and control, fire support, aviation, and logistics. Providing logistic support from a sea base may be the most challenging of these tasks.

In the lower half of Figure 2.1, the two arrows represent strategic sealift ships and maritime prepositioning ships transporting equipment to a port while strategic airlift delivers personnel and light equipment to a close-by airport. Ever

since the early 1980s, Marine Corps operations have been supported by three squadrons of maritime prepositioning ships—leased merchant ships of the roll-on and roll-off design. Each squadron is loaded with the equipment and 30 days' worth of supplies for a Marine Corps expeditionary brigade and is deployed in an area of potential conflict. When secure port and airfield facilities are available, a brigade-size Marine Corps unit can be airlifted to the theater of operations, marry up with equipment that has been unloaded from the prepositioning ships, and be prepared for combat in less than 15 days. The follow-on echelon of a Marine air-ground task force—whatever Navy and Marine Corps equipment and personnel cannot be moved to the theater of operations in amphibious warfare ships—also is moved by strategic sealift and airlift.

When maritime ports are not available or are inadequate to meet needs, the maritime prepositioning ships and strategic sealift ships are offloaded onto lighters or rapidly constructed causeways for movement of equipment ashore. Such operations, called logistics over the shore (LOTS), are depicted in Figure 2.1 by the dashed arrows above the port.

The panel speculated on the possible role of a 50-knot sealift ship to transport materiel and troops rapidly from CONUS to an area of military engagement. First principles of hydrodynamics suggest that such a large ship (length greater than 1,400 feet) operating at 50 knots would meet requirements for power and displacement hull design. Although such a large, high-speed ship might be an alternative to the maritime prepositioned ship—it would minimize the demands on strategic airlift and would make LOTS operations in sea state 3 attainable—other operational considerations do not make the concept attractive at this time. These reservations include the deep draft of the ship that limits the possible geographical areas of operations, the potential for heavy casualties when under attack, and the inability to transit the Panama Canal.

Whereas the logistic activities depicted in Figure 2.1 share the common goal of managing and moving materiel to using forces, they do so under different operating conditions and often require different capabilities—different technologies—to be effective. The following sections discuss opportunities for applying technology to improve logistic capabilities in three of the major naval logistic activities: (1) supporting naval forces at sea, (2) supporting Operational Maneuver From the Sea, and (3) conducting logistics-over-the-shore operations.

## SUPPORTING NAVAL FORCES AT SEA

The U.S. Navy supports its forces at sea more efficiently and more effectively than does any other navy in the world. The methods have evolved and been refined over many years of experience. Both connected and vertical replenishment are used for all types of ships, often concurrently. Although improvement is always desirable in the maximum weight of transferred loads, or in the separation of ships, or in extending the range of weather conditions under which replen-

ishment can be performed safely, such improvements probably are marginal. With one exception, both methods work well and are reliable. The exception is rearming the vertical launch system (VLS).

### Rearming the Vertical Launch System

The Navy's vertical launch system for missiles is rearmed by lowering a new missile canister into each launch cell, one at a time. When rearming at sea, each of these heavy missiles, in its canister, is transferred from the logistic ship using the standard alongside (connected) replenishment method. The missile canister is then manhandled over to the launcher, upended by a crane, and lowered into a cell. Even in calm seas, controlling the pendular motion of the missile dangling from the crane is difficult, slow, and dangerous. Consequently, rearming of the VLS is normally done only at pierside or in a protected harbor. Because of these limitations, the Navy has chosen not to provide an at-sea VLS rearming capability in the latest block of its newest class of destroyers (*Arleigh Burke*-class guided-missile destroyer).

Table 2.1 shows why at-sea VLS rearming rates are unsatisfactory to the point of being almost useless. Fully rearming a ship's capacity would take 17 to 35 hours—in calm seas. The Navy is working on an approach, called the transportable rearming method (TRAM), that may be able to achieve a vertical launch system rearming rate of 15 missiles per hour. The logistic ship would transfer a device to the combatant that, once the device has been mounted on rails on the missile launcher, would receive the missile canister, move it to the launch cell, and hold it in place while it is lowered into the tube. At the expected rates, full rearming would take 4 to 8 hours.

Today, missile inventories are small compared to the number of vertical-launch cells. Mission success may depend on being able to move missiles at sea from a disabled ship to one capable of performing a combat mission; from a ship rendezvousing at sea with one that is just deploying; or from a ship whose current

TABLE 2.1 Estimated Alongside Times for Replenishment

| Ship Type | VLS Missile Capacity | Current Full Replenishment Time (3.5 missiles per hour) | Full Replenishment Time with TRAM (15 missiles per hour) |
|---|---|---|---|
| CG-47 *Ticonderoga*-class cruisers | 122 | 35 hours | 8 hours |
| DDG-51 *Arleigh Burke*-class guided-missile destroyers | 90 | 26 hours | 6 hours |
| DD-963 *Spruance*-class destroyers | 61 | 17 hours | 4 hours |

mission does not depend on firing missiles to one whose mission does. Whether or not the TRAM proves to be a satisfactory solution, finding and installing in the fleet a way to rearm the vertical-launch systems at sea should be a high priority for the Navy.

In the long term, the role of missiles in naval warfare is likely to grow substantially from today's use of a small number of long-range cruise missiles and air-defense missiles to reliance on ship-based missiles for high-volume strike and close-support missions. If it does, continuing to rearm one cell at a time will not suffice. More efficient means of resupplying ships and of loading launchers will be needed. The Navy should start now to outline concepts for the design of both combatants and logistic ships that will enable rapid resupply of large quantities of missiles.

### Delivering Warfighter-Ready Stores

The emphasis in under-way replenishment is on rapid transfer of materiel from the combat logistic ship to the combatant. Once that transfer occurs, the combatant too often is left with pallets or cargo nets of stores dumped on its decks. Moving the materiel below into storerooms where it can be properly identified and located may take days, and the materiel is generally not available for use until this takes place. The strikedown and stowage process on board the combatant could be greatly speeded if materiel arrived on deck packaged, labeled, and sequenced for rapid stowage.

In the commercial retail industry, items no longer are delivered in bulk to storerooms where the retailer unpackages and price-labels them before putting them on display shelves or racks. Instead, stores demand that vendors deliver goods in shelf-ready, or rack-ready, condition, so they can be moved directly from delivery trucks, often by the vendor, to the sales floor.

The Navy could be doing the same for shipments to its warships—providing supplies that are warfighter ready. Resupply points and replenishment ships could have in computer databases information about the configuration of each ship and about its storerooms, strikedown routes, and locations of materiel on board. Shipments directly from a supply point to a combatant, which are frequently made to aircraft carriers, could be packaged and labeled expressly for the destination ship's intended storage space. Items requisitioned from the logistic ship's shopping list could be similarly packaged and labeled on board the logistic ship. All transfers from the combat logistic ship to the combatant would then be ordered in such a way as to permit the most efficient strikedown and stowage.

Future logistic processes for providing materiel to forces at sea also should exploit the advantages that containers offer to storage, handling, and movement of materiel. Loading of combat logistic ships with munitions and supplies follows the pallet-by-pallet methods of break bulk carriers that are obsolete and vanishing from commercial trade. Commercial logistic operations are turning to intermodal

(truck, rail, and ship) shipping of containerized cargo for almost all goods except bulk commodities such as wheat and coal. Whereas pallets hold 1 to 2 tons of materiel, offer poor access to individual items without breaking open the package, and provide little control of items afterward, an international standard 20-foot sea container holds 12 to 15 tons and, if properly configured and labeled, can provide ready access to its contents while retaining protected and secure storage.

Today's naval logistic system uses efficient, commercial, intermodal transport capabilities only as far as a port. There, supplies are broken out of containers, loaded as break bulk cargo onto combat logistic ships, and eventually transferred to combatants. Although transferring standard, commercial containers (8 feet × 8 feet × 20 feet) at sea and handling them on board combatants may be unrealistic, a logistic system that exploits commercial practices to the maximum extent possible would have great advantages in the efficient support of forces. For example, the Navy could move containerized materiel onto combat logistic ships, and then break out supplies into smaller shipments for transfer to combatants. The containers could then serve as "virtual" depots. Instead of being stuffed to maximize the use of volume, they could be configured internally as accessible storage, perhaps opening on the sides for access. They would then serve as on-board storerooms.

### Design of Next-Generation Dry-Cargo Shuttle Ships

The ammunition and stores ships the Navy now uses for shuttling supplies from CONUS and overseas supply points to battle groups at sea will be reaching the end of their normal 35-year lifetimes early in the next century (Table 2.2). The Navy is starting to examine alternatives for the next generation of shuttle ships. The time is opportune to look beyond the design of a logistic ship to redesigning the entire process of supporting ships at sea, with a view to reducing manpower requirements and to exploiting technologies that will be available in the next decade. The following technologies in particular should be addressed:

TABLE 2.2 Combat Logistic Force Ships

| | Number of Active Ships | Average Age (Years) |
|---|---|---|
| Ammunition ships (AE and TAE) | 7 | 26 |
| Stores ships (AFS and TAFS) | 8 | 30 |
| Oilers (AO and TAO) | 16 | 8 |
| Fast combat support ships (AOE) | 7 | 16 |

- Telecommunications and computing technologies for planning, tracking, and controlling materiel movements;
- Modeling and simulation for operational decision support;
- Automatic identification technology for marking and locating items;
- Automated stowage planning for both logistic ships and combatants;
- Automated on-board materiel handling;
- Packaging, both for warfighter-ready distribution and for minimization of waste materials; and
- Use of intermodal containers (containers that can be transported efficiently by truck, rail, ship, and in some cases, air).

## SUPPORTING OPERATIONAL MANEUVER FROM THE SEA

The Marine Corps must be prepared for a broad range of military operations. Amphibious assault, however, is the prime high-risk mission for which Marines are uniquely trained and equipped. Deploying from amphibious warfare ships in helicopters, air-cushion landing craft, or amphibious assault vehicles, the Navy can position marines to land on hostile shores and conduct military operations in virtually any littoral area in the world. Marine air-ground task forces, tailored to the mission, offer U.S. theater commanders the potent and flexible capabilities of combined land, sea, and air power. Because amphibious operations start by moving forces and supplies from ship to shore under trying and often hostile conditions, these operations are always difficult to support logistically. As the Marine Corps moves toward its concept of Operational Maneuver From the Sea, conventional logistic capabilities will be stretched to their limits and, in many cases, will fall short of providing the support demanded by combat operations. Technology must play a role in creating new logistic capability. Thus, it is on logistical support of Operational Maneuver From the Sea that the panel concentrates (Figure 2.2).

### Logistical Implications of Operational Maneuver From the Sea

As the Marine Corps defines its concept for Operational Maneuver From the Sea and the types of equipment and forces it will employ, logistic needs will change dramatically from today's.[1] Current sustainment requirements for two notional Marine Corps forces are shown in Table 2.3. The experiments that the Marine Corps is conducting with new tactics (e.g., Sea Dragon) have at their very core substantial reductions in the sizes and types of units placed ashore. By

[1]The logistic implications of Operational Maneuver From the Sea were explored in the Naval Studies Board report *The Navy and Marine Corps in Regional Conflict in the 21st Century,* National Academy Press, Washington, D.C., 1996.

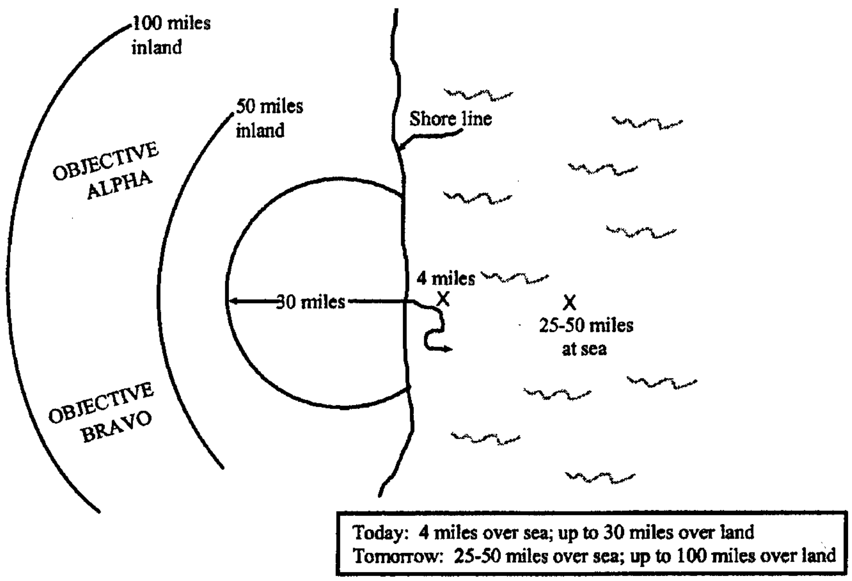


FIGURE 2.2 Operational Maneuver From the Sea.

keeping as much command and control, fire support, aviation, medical services, and logistics at sea for as long as possible, shore operations and the need for logistical support will be reduced primarily to that of combat maneuver units. The large cantonment areas, airfields, fuel and ammunition storage areas, hospitals, headquarters, and other support facilities will not be needed ashore, nor will the communications, transportation, protection, and other services that large populations of support personnel require. Thus, by not putting support functions ashore, the logistic workloads associated with supporting them there will be avoided, which will reduce the logistic "footprint."

Equipment design also will play an important role in determining future support requirements. The Marines will look to technology to provide combat equipment that is much easier to transport and much more reliable and maintainable than today's. They will strive to exploit the airlift capabilities of the Osprey (MV-22) tilt-rotor aircraft and the heavy-lift helicopter (CH-53 or its successor), the landing craft, air-cushioned (LCAC), and the advanced amphibious assault vehicle (AAAV) to move and support Marine Corps units ashore. Having equipment such as combat vehicles, artillery, and material handling equipment that can be moved readily by these two aircraft and by the LCAC will be essential to effective operations.

Yet, even if the quantities are smaller, supporting Operational Maneuver

TABLE 2.3 Amphibious Force Sustainment Requirements (short tons per day)

| Class of Supply | Marine Expeditionary Unit (short tons/day) | Marine Expeditionary Brigade (short tons/day) |
|---|---|---|
| Subsistence | 42.3 | 375.1 |
| General supplies | 39.2 | 235.2 |
| Petroleum oils and lubricants | 8.8 | 56.9 |
| Barrier materials and bulky supplies | 0.4 | 3.8 |
| Ammunition | 187.4 | 562.1 |
| Major items | 18.1 | 72.4 |
| Medical | 17.2 | 58.5 |
| Spares and repair parts | 21.6 | 121.0 |
| Total | 335.0 | 1,485.0 |

SOURCE: Headquarters, U.S. Marine Corps. These planning factors are under revision. New sustainment requirements will probably be lower than those shown here.

From the Sea will require some major changes in the way logistic operations are performed. The Navy and Marine Corps must learn to perform at sea the logistic functions traditionally performed in the beach support area. For example, one of the purposes of the beach support area has been to receive and store bulk shipments of supplies, then break them out for distribution. The Navy has only limited at-sea capability to provide this essential distribution function for sizable Marine Corps operations.

Logistic bases ashore, if any, may be primarily for fuel and munitions and may be temporary—that is, relocated frequently to better support combat operations and present only fleeting targets to the enemy. Combat units may be widely dispersed, making traditional support operations infeasible. Logisticians will have to think in terms of mobile supply points that rendezvous with combat units, rather than of traditional logistic bases and main supply routes. With ships operating offshore and combat units well inland, supply lines, both over water and over land, will be longer as shown in Figure 2.2. Land routes may offer the greatest challenge because land lines of communication may be securable only temporarily, if at all.

Meeting the logistic challenges of Operational Maneuver From the Sea requires thinking through the entire process of supporting amphibious operations—what has to be done and how it might be accomplished. The Marine Corps has indeed begun to assess the logistic requirements and implications of OMFTS. For example, the recent Hunter Warrior series of experiments, in part, examined some of these issues, as did the Naval Studies Board in its recent study on

regional conflict in the next century.[2] Although it may be too early in the development of the concept to be precise, it is clear that new capabilities will be needed in at least three key areas: (1) logistic command, control, and communications; (2) sea-basing of platforms; and (3) ship-to-unit transport of supplies. These key areas are discussed in turn in the following sections.

### Logistic Command, Control, and Communications

Logistic operations in the fast-changing, mobile warfare environment envisioned by Operational Maneuver From the Sea will have to be thoroughly but rapidly planned, tightly controlled, and precise in delivering the support required when and where it is needed. Data, communications, and automated decision-support aids will be the lifeline of logistic operations.

Logistic commanders and staffs will require timely information on the tactical and logistic situations, the location and status of logistic assets, and the implications of current and alternative courses of action. They will need much of the same information about friendly and enemy forces that operations staffs have—maps, disposition of friendly and enemy forces, weather data, and operations plans. In addition, they will need data on the location and condition of roads, rail lines, ports, and storage areas. Finally, they will require complete information about logistic assets—for example, location and condition of supplies, status of en route shipments, and location and status of transportation and materiel handling equipment. Technologies for automatic identification and tracking of shipments; for monitoring truck and materiel handling equipment performance; for automatically reporting expenditure by supported units of ammunition, fuel, and other supplies; and for monitoring logistic processes—all of these will have direct application.

Logisticians will also need the means to use effectively the vast amounts of data available to them. They will have to develop the knowledge-based decision aids—models, simulations, and algorithms—that will enable early recognition and anticipation of logistic requirements; identification, assessment, and selection of alternative courses of action; and monitoring of the status, progress, and performance of logistics. Creating these tools will require both new technology and attention to the decision rules that define how logistic processes will work.

Long-range, secure, assured communications for command and control of logistic operations and for exchange of logistic data will be essential. Today's logistic operations at the tactical level are conducted primarily via voice radio. Tomorrow's logistic operations will depend on a steady stream of digital data updating files on unit locations, supply status, equipment performance, parts

[2] Naval Studies Board. 1996. *The Navy and Marine Corps in Regional Conflict in the 21st Century*, National Academy Press, Washington, D.C.

availability, shipments, and the myriad of other details necessary to coordinate logistic activities. To meet the needs of Operational Maneuver From the Sea, logistics will require the same high priority for communications traditionally reserved for operational and intelligence traffic. Ensuring that the databases and communications networks are free from penetration and contamination also will be as essential for logistic data as it is for operational and intelligence data.

### Sea-basing of Platforms

If logistical support of forces ashore is to be based at sea, the Navy and Marine Corps must be able to perform—25 to 50 miles at sea and in large enough volume—the maintenance and materiel distribution functions now performed ashore. These include receipt, repair, storage, breakout, packaging, and shipment—the basic logistic functions. The size of the sea-basing requirement will depend on the size of the force being supported and on the duration of sea-based support. Today, naval forces can support special operations teams from their amphibious warfare ship sea base almost indefinitely, although most missions are of short duration. Since an amphibious ready group normally has on board 15 days' worth of supplies for its embarked Marine Corps expeditionary unit (a 2,000-marine air-ground team consisting of a composite air squadron and a reinforced ground battalion), it probably could support such a unit for some time without a beach support area, but for just how long is uncertain. The ships are not normally loaded with long-term maintenance and sustainment operations in mind. In any case, supporting a large force for an extended period—for example, a brigade for 30 days—is clearly beyond current capability. Several alternatives seem worth exploring:

- *New-design amphibious warfare ship.* Amphibious warfare ships are basically logistic ships designed for transporting and disembarking Marine Corps units. They have good offloading capability in their well decks and helicopter decks. They have good command, control, and communications for both the Navy and the Marine Corps. Once the Marine Corps units are disembarked, the support ships have considerable unused space. What they lack for the sea-basing function is the storage and materiel handling capability needed to sustain a sizable operation. A new-design amphibious warfare ship may be able to accommodate both the current amphibious landing role and the sea-basing sustainment role.
- *Amphibious warfare ship paired with a combat logistic ship.* A combat logistic ship has the storage and materiel handling capabilities that today's amphibious warfare ships lack. It is a seagoing supply depot. It can transfer fuel and cargo to other ships at rates sufficient to support operations of a battalion-sized unit. However, it lacks the amphibious warfare ship's well deck for discharging cargo via lighter and sufficient flight deck capacity for sustained heavy-lift heli-

copter operations. By pairing the two types of ship, the unique capabilities of each could be exploited. The combat logistic ship could perform the essential storage, breakout, and packaging of materiel and then transfer it to the amphibious warfare ship for movement to Marine Corps units. Although the loads that the combat logistic ships now carry are not tailored to marines' needs, these loads could be adjusted. However, cargo would have to be handled twice, once on the logistic ship and again on the amphibious warfare ship.

- *Amphibious warfare ship paired with a maritime prepositioning ship.* This is a variation on the previous concept. Its advantage is that the maritime prepositioning ship is dedicated to carrying Marine Corps equipment and supplies. However, right now, these ships are not configured for under-way replenishment operations. For instance, materiel is not stored to permit selective offloading; the ships are of the roll-on and roll-off design, better suited to deploying forces than to sustainment operations; and they lack the crew needed for materiel handling and distribution. All of these could be changed if the Marines want these ships to perform the dual missions of prepositioning and sea-basing. Because leases for the current maritime prepositioning ships expire in 2010, now is a good time to explore options for the ships' use and design.

- *Sea-based support ship.* A new ship class specifically for the sea-basing mission could be designed. Figure 2.3 depicts a concept for a ship having the principal features desired for sea-basing, that is, automated container handling, stowage, and retrieval; workspace for breaking out and repackaging; hangar space for maintaining aircraft or other equipment; heavy-lift helicopters; well-deck for lighters or air-cushion vehicles; and an unobstructed 900-foot flight deck. Also included in the concept by its originator was a new-design, fixed-wing, container-carrying aircraft. The sea-based support ship would be a large ship, designed for storing and distributing supplies in large quantities. Additionally, it would contain the necessary communications and computer capacity to provide a logistic operations center.

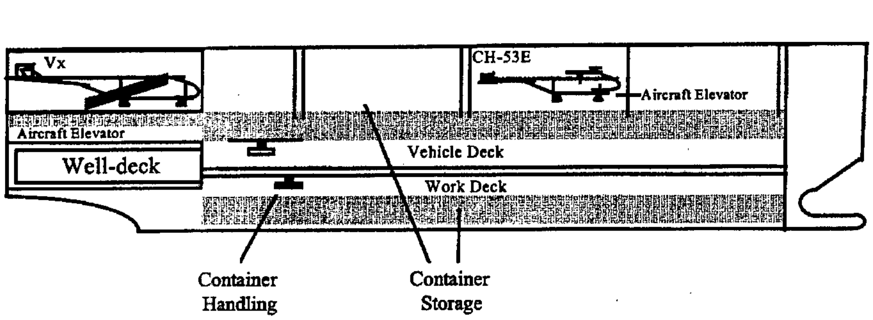


FIGURE 2.3 Sea-based support ship. SOURCE: AGRILOG, Inc. 1995. *Marine Corps Logistics "2010,"* prepared for Naval Facilities Engineering Center, December 1.

• *Mobile offshore base.* From time to time, proposals have been made to adapt the technology of offshore oil-drilling platforms to the construction of platforms that could serve as offshore bases for military operations. Several different concepts exist. They share the notion of connecting a half-dozen or more very large, semisubmersible modules to form a mobile floating airfield long enough to handle military transport aircraft (5,000 feet for a C-17).

The size and construction of the modules would make them very stable in the roughest seas. They would have cranes and ramps for unloading merchant ships and for transferring loads to shallow-draft lighters. Their spaces could be used for fuel and cargo storage, materiel handling, maintenance, billeting, and other support activities.

Tests indicate that although they are not as mobile as ships, the modules could be self-deployable. Technical unknowns, however, still have to be resolved. Platforms of this size never have been constructed. The largest drilling platform now in existence, the Gorilla V, is one-half to two-thirds the size of a single module and is of a jack-up design, not a semisubmersible. Also, such large floating objects have never been linked together. Furthermore, wargames indicate that a mobile offshore base might present an inviting target for early enemy attack. Nevertheless, if such a floating platform proves technically feasible for a reasonable cost, it could provide the Marines an excellent sea-basing capability, especially for humanitarian relief, peacekeeping, and operations other than war. It could serve the combined purposes of maritime prepositioning, offshore staging, and sea-based sustainment of Marine Corps operations.

Selection of the best alternative for a sea-based platform is not possible without definition of Marine Corps operational requirements, careful assessment of the current limits on supporting units from amphibious warfare ships, conceptual designs of ship options, and analyses of the cost-effectiveness of alternatives. The panel believes that because of cost and mobility considerations, a new ship design is likely to serve the needs of naval forces better than a mobile offshore base. Further, a multipurpose ship design, combining the features of a prepositioning ship, a sea-based support ship, or possibly an amphibious warfare ship, is likely to be the better choice. In any case, the Navy and Marine Corps should define future sea-basing and maritime prepositioning needs and should start exploring ship designs that will satisfy these needs.

## Ship-to-Unit Transport

Operational Maneuver From the Sea will extend the distances between deployed units and their sea base of logistic support. Support of widely dispersed units well inland, without secure land lines of communication, will place a heavy logistic workload on air transport and high priority on protecting air lines of communication from enemy and aircraft fires. A large proportion of aircraft

sorties will be allocated to resupply missions. The heavy-lift helicopter (CH-53 or its follow-on) will likely be the workhorse. Although the CH-53's payload is ample for the purpose when operating over short ranges under ideal conditions, some upgrade will be needed to provide adequate payload capability over longer distances and in a broader range of operating conditions.[3] The tilt-rotor aircraft now under development (MV-22 Osprey) will probably be needed often for logistic missions. Precision airdrop and unmanned air delivery vehicles could complement vertical-lift capabilities. Because the range-payload characteristics of helicopters and tilt-rotor aircraft will not be adequate, eventually a new-design very-short-takeoff-and-landing tactical transport aircraft is likely to be needed to span the distances modern warfare creates between logistic bases and maneuvering combat units.

Although the concept of Operational Maneuver From the Sea would have no beach support area as now practiced, moving all supplies from ships 25 or more miles offshore directly to units well inland may not always be necessary or possible. Using efficient watercraft transportation to establish small, perhaps temporary, resupply points along the shore could greatly reduce the burden on air transport. With ships 25 or more miles off the coast, however, the 12-knot utility craft (LCU 1600) now carried with amphibious ships will be of only limited utility. The ship-to-beach transport burden will fall on LCACs, which, with their 60-ton payloads and 25- to 40-knot speed, are very capable. However, an LCAC is expensive to operate ($3,000 per hour), and its aluminum construction makes it somewhat vulnerable to damage. A relatively inexpensive, durable, high-speed lighter would be a valuable complement to air-cushion vehicles. Figure 2.4 shows such a craft, a sea sled, which would fit two abreast in the well-decks of amphibious warfare ships, carry a payload of nearly 200 tons, and maintain a speed of 30 knots with full load and 40 to 45 knots empty.

Fuel and water pose the toughest transport problems. When distances exceed the length of a hose or of a rapidly installed pipeline, as they will under Operational Maneuver From the Sea, new means must be devised for both ship-to-shore transfer and distribution to units. One approach might be to use large bladders on board air-cushion vehicles or lighters as mobile supply points to rendezvous along the coast with tanker-design helicopters or combat logistic vehicles that would distribute the liquids to maneuver units inland. Such a concept would use the efficient water transport at least as far as possible, shortening the transport leg that must be accomplished by air or ground vehicle.

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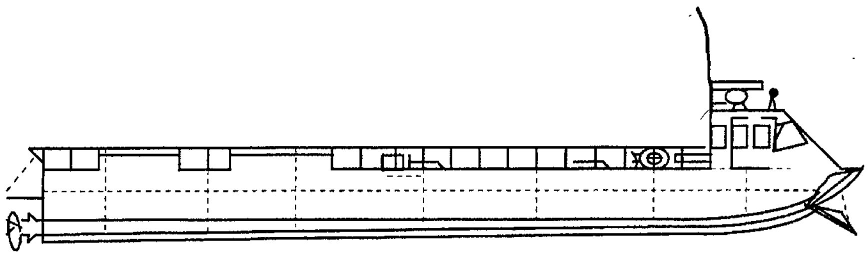
[3]The CH-53 has a maximum payload of 32,000 pounds over an operating radius of 50 nautical miles at sea and 90°F. The maximum payload decreases with range, although it is capable of inflight refueling.



| | | | |
|---|---|---|---|
| Length | 146' 6" | Crew | 4 |
| Beam | 23' 0" | Gross Weight | 525,000 lb |
| Draft | 3' 9" | Payload | 365,000 lb |
| Main Power Plant | 8,000 hp | Speed (full payload) | 30 knots |
| | | Speed (no payload) | 40-45 knots |

FIGURE 2.4 Sea sled. SOURCE: Adapted from John K. Roper and Daniel Savitsky. 1982. "Conceptual Study of Simplified Landing Craft for Amphibious Vehicles (Summary Report)," Technical Report No. SIT-DL-82-9-2314, Davidson Laboratory, Stevens Institute of Technology, Hoboken, N.J.

## CONDUCTING LOGISTICS OVER THE SHORE

Although much attention is given to supporting the assault echelon of an amphibious landing, most logistic operations in support of the Marine Corps are likely to be conducted under relatively benign conditions. That is, the offloading of equipment and supplies from ships will not occur in the face of strong enemy opposition (although raids, saboteurs, and occasional missile attacks might not be ruled out). The maritime prepositioned equipment and the assault follow-on echelon are transported in merchant ships that require a secure environment for unloading.

When possible, unopposed landings will take place at established ports, using commercial port facilities. In much of the world, however, port facilities are inadequate to handle the rapid influx of a large U.S. military force. Even where good facilities may have once existed, at the time of the landing they may have deteriorated or been too heavily damaged to meet military offloading requirements. In such situations, ships are unloaded onto lighters or rapidly assembled causeways for movement of cargo ashore. These operations are termed "logistics over the shore."

Logistics over the shore is conducted over unimproved shorelines or through fixed ports that are either inaccessible to deep-draft shipping or inadequate to handle the required throughput. The operations are conducted as close to shore as possible, preferably in a protected harbor. In-stream operations are typically 1 to 3 miles offshore. Greater distances increase lighterage transit time, thereby decreasing daily offload capacity, and also increase vulnerability to adverse sea state conditions.

Both the Army and the Navy maintain logistics-over-the-shore capabilities, although with somewhat different emphases. The Army, with its focus on theater waterborne logistic support and coastal transportation operations, relies primarily on the logistic support vessel (LSV) and the LCU-2000 utility landing craft. The Navy, with its focus on support of amphibious operations, relies primarily on floating and elevated causeway systems. Both Services maintain a variety of tugs, floating cranes, barges, and other floating craft to perform such critical functions as docking sealift ships, performing heavy lifts, clearing channels, and discharging petroleum. The capabilities of both are needed to meet joint requirements for major contingencies.

The major shortcoming of today's capabilities for conducting logistics over the shore is that they are severely limited by adverse weather or rough seas. Sea state 3 conditions bring offloading to a halt, and such conditions (or worse) prevail almost half the time in many areas of the world where future military operations may be conducted. In Korea, for example, sea state 3 or greater prevails 43 percent of the time in summer and 63 percent in winter.

A number of developing technologies aim to overcome this environmental limitation. Stabilized cranes are being designed to move cargo safely from ships to lighters. Improved, modular causeways with higher freeboard are being developed to permit transport of equipment and cargo in rough seas. Roll-on and roll-off discharge facilities are being developed to enable efficient offloading of roll-on and roll-off ships. Experiments with rapidly installed sea barriers seek ways to dampen waves in the immediate area of unloading operations. Concepts for portable ports seek to develop means for quickly constructing piers that would enable ships to offload without using lighterage.

Development of sea state 3 logistics-over-the-shore capabilities should remain a high priority. Even with the emphasis that the Marine Corps is placing on supporting its operations from the sea, the ability to conduct over-the-shore operations efficiently will remain critical to the rapid buildup of combat power ashore and the rapid withdrawal of forces for commitment elsewhere.

# 3

# Supporting Weapon System Readiness

The steps to maintaining equipment are well known. Reliable equipment does not break down frequently. When it does, well-designed equipment is repaired easily and can be returned to use quickly. If the cause of failure is easy to discover and the maintainer has the needed training, tools, parts, and instructions, no time is wasted.

However, performance-driven design has frequently created obstacles to designing and producing the kind of reliable, maintainable equipment the Navy and Marine Corps would like to have. There are also obstacles to having all the correct maintenance resources at the right place at the right time to do repairs. The Navy and Marine Corps have learned, also, that time-based preventive maintenance is often excessive and can even cause, rather than prevent, problems. The penalty paid for excessive maintenance is lower-than-desirable readiness at higher-than-necessary cost.

Maintaining the readiness of weapon systems is a major activity of naval forces. Forty-seven percent of the Navy's active duty enlisted force (173,000 sailors) and 24 percent of the Marine Corps (37,600 marines) are assigned to maintenance functions.[1] The direct maintenance cost of aircraft and ships is at least $15 billion per year.[2] Reducing the necessary maintenance needed and the

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[1]Calculated from FY 1995 data drawn from the Office of the Undersecretary of Defense (Personnel and Readiness), Defense Manpower Data Center, Seaside, California.

[2]Naval Center for Cost Analysis. 1996. *NAVYVAMOSC: Navy Visibility and Management of Operating and Support Costs,* Department of the Navy, Washington, D.C., June.

learning required to perform it more effectively and efficiently could have substantial payoff in freeing up personnel and budgets for other needs.

Applications of technology have enabled weapon systems that not only perform more effectively but also are more reliable and more maintainable than their predecessors. Part of this trend is attributable to a natural evolution of technology—for example, the replacement of vacuum tube electronics by solid-state devices and the replacement of steam turbine engines in ships by gas turbines. The panel expects such trends to continue with, for example, next-generation gas turbine engines, replacement of much hydraulic and mechanical equipment with electromechanical devices, and possibly even the development of electric-drive ships. The panel notes also plans to reduce the numbers of different types of ships, aircraft, and other weapon systems in the forces. Such consolidations should have a marked and beneficial effect on logistic workloads.

Given whatever logistic workloads the design of forces and weapons presents, however, the panel believes that the greatest beneficial impact on readiness will come from exploiting information technology to improve logistical support practices. Information technology promises to change fundamentally the way logistic activities are performed. It will provide all participants in the business of producing and supporting weapon systems the knowledge to make "best" decisions throughout a weapon's life cycle. This access to information, when and where needed and in the form needed, will enable the logistic system to function as an integrated process focused on weapon system readiness.

The key over the next 5 to 10 years will be managing the various applications of information technology in a way that, in fact, creates the integrated process that is possible. This will entail using information technology to bring together the acquisition process, configuration management, computer-based maintenance training, troubleshooting and repair, equipment performance monitoring, and parts supply. In the following sections, the panel describes how information technology can change the way logistic tasks are accomplished in each of the above-listed areas and how it can contribute to creating a simulation-based acquisition (SBA) process to enhance weapon system readiness.

## ACQUISITION PROCESS

Logistic considerations traditionally and, in part, necessarily have followed performance considerations in the design and operation of weapon systems. Development of support equipment, technical data, training packages, and provisioning plans could not be pursued in earnest until system designs had stabilized. Logisticians were presented with a design they were to support, having had little input into its reliability or maintainability characteristics. The support system that evolved often was poorly matched to the weapon system it supported and often remained that way throughout the system's life. The result was a cumber-

some logistic system that incurred many unnecessary costs and often was slow to respond to readiness requirements.

Modern acquisition programs are abandoning paper-based design process, including technical drawings, in favor of computer-based processes. These have at their core a single, integrated, digital weapon system database that can be accessed, via computer networks, by all participants in the acquisition process, permitting real-time collaboration on design features.

By "single, integrated" is meant not literally one database in one computer, but a single set of data in which each data element, no matter who creates it or where it is stored, is entered and maintained as part of an integrated set and utilized in common by all users. No longer do the designers, manufacturers, trainers, personnel managers, and logisticians each need to create and maintain their own databases, often duplicating (imperfectly) data used by the others. These principles are being incorporated into the current design of ships (LPD 17) and aircraft (joint strike fighter [JSF]).

To the logistician, the creation and use of a single digital database enable two key logistic activities to be accomplished concurrently and interactively with weapon system acquisition:

- Assessment of logistic features and their implications, and
- Design and development of logistic and training support package.

Prior to design, the mission employment of a weapon system and its support concept can be simulated to determine key reliability and maintainability features. Initial designs can be simulated in virtual reality, directly from the computer-aided design database, to check such features as access to components for maintenance and vulnerability to battle damage. Working from the design database, logistic engineers can identify design-induced logistic problems early and feed them back to design engineers for correction. This ability to influence equipment design is critical to a weapon system's readiness throughout its life because there is no substitute for high reliability. (This is an important aspect of simulation-based acquisition (SBA), a process described more fully in *Volume 2: Technology* of this nine-volume study.) Design of the support system—maintenance concept, test equipment, test software, diagnostic and repair procedures, and training materials, devices, and aids—can proceed concurrently with system design. Provisioning decisions can then be made on the basis of detailed design data and test information.

Use of these information technologies—simulation and single, integrated digital design databases—during the acquisition process will enable procurement of weapon systems designed from the outset for efficient and effective support and of support systems matching the weapons they are intended to support. Effective employment of information technology will result in placing into users'

hands weapon systems that can be operated for maximum effectiveness at minimum life-cycle cost.

## CONFIGURATION MANAGEMENT

One of the most important benefits of a single, integrated weapon system database is having in place the capability to manage a weapon system's configuration throughout its lifetime. Imperfect knowledge of system configuration builds inefficiencies into the foundation of the logistic system. Stocking spare parts, issuing technical data, and training technicians become expensive guessing games when the true configuration is uncertain.

The single, integrated weapon system database offers the starting point for establishing sound configuration management. The challenge then is to keep that database current throughout the system's life. Technology for marking components will enable identification and, in some cases, recording of operating or maintenance history. Technologies range from barcoding to etchings to microchips embedded in or affixed to components. Some systems, especially electronics, will have a built-in capability for automatically sensing and reporting the identity of their components. Establishing and maintaining accurate configuration data on older systems will still be difficult, but it is essential to efficient functioning of the logistic system.

## COMPUTER-BASED MAINTENANCE TRAINING

Information technology not only can improve classroom training but also can move much of the item-specific training out of the classroom to the technician's job site. Studies show that training times in school situations typically can be reduced up to 30 percent[3] by enhancing traditional instruction with self-paced, interactive, computer-based training. Learning does not suffer; in fact, it improves.

Once training is computer based, it can be exported from the classroom to the job site, saving instructor and student time and costs. So-called distance learning could be made available to technicians over a computer network, permitting them not only to learn new skills but also to refresh or enhance their skills without returning to school.

Computer-based training can be made even more effective by integrating it with the digital technical data used for diagnostics and repair, providing the

[3]Orlansky, Jesse, Carl J. Dahlman, Colin P. Hammon, John Metzco, Henry Taylor, and Christine Youngblut. 1994. *The Value of Simulation for Training,* IDA Paper P-2982, Institute for Defense Analyses, Alexandria, Va.

technician with training that matches perfectly the equipment to be maintained, the task at hand, and the technician's skill enhancement needs.

## TROUBLESHOOTING AND REPAIR

The Navy has had an aggressive and successful program to eliminate the need for technical manuals on board ships by digitizing technical data. The current storage medium is primarily compact disk. Digitized data are not only easier to move and take much less storage space than traditional manuals but also easier to keep current and to access.

Today's digitized technical data are produced mostly by scanning paper-based technical documents. Tomorrow's data will be designed as interactive aids to troubleshooting and repair activity, anticipating the technician's needs and presenting the information in the best order and form for the task at hand. Eventually, such "interactive electronic technical manuals" will use three-dimensional graphics to help in visualization of information and instructions.

In the future, digital technical data will be available to the technician directly from all sources that have information about the specific equipment being maintained—by type, model, series, manufacturer, production lot number, and serial number. The data will be specific to the item, not generic to the class of equipment, and will include not just drawings and instructions, but also up-to-the-minute status, diagnostic, and repair information drawn from worldwide sources and processed by autonomous or semiautonomous information systems designed to best match the information to the technician's needs.

Some information will come directly from the weapon system's sensors and built-in test equipment, some from on-board databases, some from remote databases maintained by the depots or contractors, and possibly some from engineers who are monitoring the situation remotely (see Figure 3.1).

The technician's readout device (display) will be portable enough to be taken or worn to the site of the maintenance action. It will download data directly from the weapon system or from the on-board communications network. It will provide interactively the information that the technician needs to assess the system's performance, make any adjustments, diagnose malfunctions, order parts, and make repairs. It will be tied electronically to the supply source so that the correct part can be identified, ordered, and provided, all without the need for error-prone manual input of data. Maintenance actions, successful and unsuccessful, will be recorded automatically in the master configuration management database and will be available for use in assessing equipment maintenance needs, technician training, and redesign requirements.

Early tests of these concepts are demonstrating great potential for improving maintenance. For example, a study done at the Air Force's Armstrong Laboratory compared the performance of maintenance technicians using standard paper-based technical orders (TOs) with that of others using an integrated maintenance

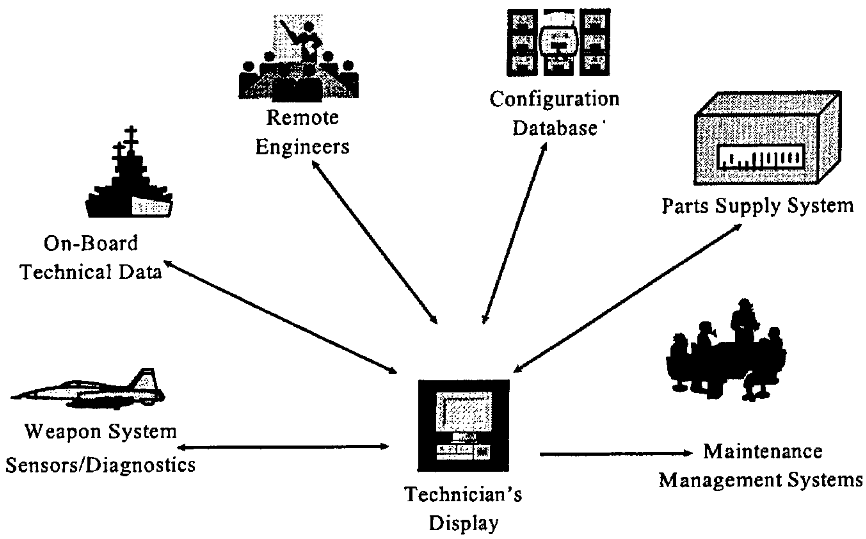


FIGURE 3.1 Troubleshooting and repair information.

information system consisting of interactive electronic technical manuals, having connectivity with maintenance data systems, and utilizing dynamic diagnostics. Results showed that technicians using the Integrated Maintenance Information System (IMIS) were more successful in diagnosing problems, made fewer errors, used fewer parts, and completed tasks more quickly.[4] The results also showed that when using the IMIS, a general technician could perform almost as well as a specialist—in fact, better than the specialist could when using the old-style TOs. The Navy's experience with the shipboard condition assessment system shows similar results, i.e., both a significant decrease in preventive maintenance time and a reduction in troubleshooting time.[5]

## EQUIPMENT PERFORMANCE MONITORING

The next major advance in equipment maintenance will be the ability to

[4]Teitelbaum, Daniel, and Jesse Orlansky. 1996. *Costs and Benefits of the Integrated Maintenance Information System (IMIS),* IDA Paper P-3173, Institute for Defense Analyses, Alexandria, Va., May. Data reported by Donald L. Thomas. 1995. *Integrated Maintenance Information System (IMIS): User Field Demonstration and Test,* Armstrong Laboratory, Wright Patterson Air Force Base, Ohio, October.

[5]Naval message No. 2718512, February 1996, to USS *Cape St. George,* from RUCBTFA/COMNAVSURFLANT, Norfolk, Va., Integrated Condition Assessment System (ICAS) Data Collection Report.

anticipate equipment failures so that they either can be avoided by preemptive action or else can be repaired promptly when they occur. Sensors embedded in equipment will monitor critical parameters during performance (e.g., temperature, pressure, vibration, stress, and wear). Data from sensors will be matched to design standards or performance characteristics of other similar equipment to detect trends portending equipment wear or failure. (For a more complete discussion of sensors and materials, see *Volume 2: Technology* of this nine-volume series.)

In some cases, equipment performance monitors may work with computer controls to "self-adjust" the equipment to optimize performance. In other cases, the data will be transmitted from the equipment while it is in use to a maintenance base or performance monitoring center, enabling technicians or engineers to alert operators regarding equipment conditions or to prepare for maintenance actions. Importantly, equipment performance monitoring will help avoid unnecessary maintenance actions, saving maintenance resources and reducing the risk of maintenance-induced damage.

## PARTS SUPPLY

Assured, secure, worldwide communication of digital information will enable shared knowledge and use of inventories among ships of a battle group, fleets, shore installations, other U.S. military organizations, allied forces, and commercial suppliers. Sparing tailored to the configuration, mission, and history of each ship, aircraft, vehicle, or other major equipment will help ensure maximum readiness benefits per dollar spent on inventory. Real-time tracking of items in shipments will permit anticipation of parts arrivals, detection of delays or misshipments, and adjustment of priorities.

Rapid distribution of spare parts will maximize productive utilization of high-value assets and minimize weapon system down time.

Intelligent software and decision-support systems will simplify, speed, and improve management actions to align parts supply with readiness priorities. Techniques for rapidly manufacturing parts will provide responsive sources of resupply for some out-of-production, low-demand, or long-lead-time items. The combination of digitally controlled manufacturing and the ability to communicate digital technical data worldwide might also allow some parts to be manufactured locally. The payoff from exploiting information technology in acquiring and managing parts will be responsive, often anticipatory, support of weapon system maintenance activities and efficient use of suppliers and inventories.

As these logistic processes become more efficient and responsive, and commanders gain confidence in them during peacetime deployments and exercises, information and rapid distribution of parts will increasingly substitute for today's large inventories at operational sites.

## CREATING AN INTEGRATED WEAPON SYSTEMS READINESS PROCESS

The Navy clearly is taking the first steps toward developing the technologies described above. The technology core of the "Smart Ship" project is the Integrated Ship Information System (ISIS) that ties together—via an on-board optical-fiber local area network—machinery control, condition assessment, damage control, and access to configuration, maintenance, and other technical data. The Integrated Condition Assessment System (ICAS) part of ISIS performs the condition monitoring, troubleshooting, information retrieval, parts ordering, and maintenance action recording.

In aviation systems, a technology demonstration project called Aviation Maintenance Integrated Diagnostics Demonstration (AMIDD) is applying some of these techniques to the F/A-18. An advanced-concept technology demonstration project has been approved recently to develop a health-monitoring system for the rotor hub of the H-60 helicopter.

The new Joint Strike Fighter program is at the forefront in just about all of these areas. The new class of amphibious warfare ship, LPD-17, is following this same model. The same is true for the Marine Corps' advanced amphibious assault vehicle and the V-22 Osprey aircraft.

Similarly, the Navy's Supply Systems Command is developing systems for tracking shipments and sharing inventories among ships and installations, all focused on reducing inventories at operational sites.

Many of the information technologies described by the panel will come with the natural evolution of management information systems and new weapons. For example, the storage and distribution of data will come more easily as the Navy and Marine Corps move to modern, distributed information systems, networks, and telecommunications.

Some investment and a determined effort will be required to infuse the following technologies into systems:

- *Sensors,* to monitor equipment performance parameters;
- *Item identification marking,* to permit accurate and, when possible, automatic configuration control;
- *Automatic data capture,* to gain timely, accurate data on logistic activities;
- *Intelligent sensors and software built into logistic processes,* to monitor status and performance and to aid process flow; and
- *Advanced user interfaces,* to enable the technician to more easily use computer-based information (e.g., language recognition, artificial intelligence, and advanced displays).

Pulling these many technology applications together to create an enterprise

process focused on weapon system readiness will be the key to exploiting the capabilities they offer. It will not be a trivial undertaking. Private-sector companies that are exploiting these technologies warn that patching new technology onto old processes is of only marginal benefit. New ways of doing business have to be designed to exploit the technology. Traditional roles and responsibilities in the organization often have to be cast aside. Investments are needed that may not offer adequate payback incrementally but are essential to the new processes. Furthermore, changes such as those envisioned here take time (perhaps up to 10 years) and relentless determination by top managers.

The most difficult tasks will be those not tied directly to new weapon programs or platforms. Justifying the funding to retrofit new technologies into old systems or to change common support processes is the real challenge. For example, common test equipment, support equipment, maintenance management, and training serve many weapon program managers but often are not of high enough priority in any single program to get funding: "Let somebody else pay for it." Acquiring new, high-visibility weapons almost always takes priority in the budget over fixing the old, but laying in the infrastructure and investing enough in old systems to make them compatible will be essential to creating the new process that is possible. The overarching long-range plan and architecture will signify a commitment to process change and will highlight the unpopular, but necessary, investments for success.

Information technology promises to change fundamentally the way logistic activities are performed and managed. If this technology is properly introduced and funded at all levels of the logistic chain, significant cost savings could be realized while providing far better service to the warfighter.

There is clear evidence that the Navy is embracing information technology at almost all levels of the total logistic process, starting with acquisition and continuing through parts supply, troubleshooting, and repair. However, without the technology system architecture and standardization of certain key aspects, suboptimization is the best that can be expected—not overall process redesign such as that achieved by truly world-class enterprises. Without the system architecture and such key elements as single, integrated databases, the cost of incorporating and maintaining currency will be burdensome to the Navy, and the benefits will fall far short of expectations.

Creating such a process will entail designing an architecture that defines how the various activities should relate to each other and to the ultimate goal of supporting readiness. This means not an acquisition process, a training process, a maintenance process, and a supply process but instead a single process that integrates all these functions to serve a common purpose. Databases, information systems, and communications systems must all work together to support weapon readiness activities. It will be necessary to formulate a plan—a path of evolution—based on architecture that will guide the development of essential capabili-

ties and investments over the next 10 years. The plan should cut across the Navy Department and embrace the Navy, Marine Corps, hardware systems commands, Supply Systems Command, Naval Training Command, and the fleets. The plan should recognize that the other Services, various defense organizations, several government agencies, and many commercial firms play essential roles in supporting naval systems.

# 4

# Conclusions and Recommendations

## CONCLUSIONS

Logistics, on the scale required to support naval forces in a littoral region halfway around the world, is an immensely complex and difficult undertaking, performed always under trying and often hostile conditions. The conditions of the future promise to be no less challenging, and in some respect perhaps more so, than those of the past. Only responsive, focused logistic activity will enable military operations within the action time lines needed for mission success. Meeting these high expectations in the future will require new logistic capabilities and new ways of accomplishing logistic tasks. Technology will play essential roles in both.

Information technology is likely to offer the greatest leverage in creating the logistic system of the future. It will offer logisticians at every operational level the data to anticipate or respond to logistic needs, to assess and select the best courses of action, to make the best use of logistic assets, and to control the flow of logistic support. The panel highlights three areas in particular that it believes can benefit substantially from the use of information technology: (1) planning and controlling the flow of supplies to naval forces at sea, from the sea, and over the shore; (2) providing the logistic command, control, and communications needed to support Operational Maneuver From the Sea; and (3) maintaining weapon system readiness.

Advances in handling and transport of materiel also will be necessary to support the type of military operations expected in the future. The major new challenges that technology must address are (1) rearming missile launchers at

sea; (2) providing a sea-based support platform, low-cost, robust, high-speed watercraft, and air transport to support the Marine Corps concept of Operational Maneuver From the Sea; and (3) conducting logistics-over-the-shore operations in rough seas.

The full benefit from technology, however, will be gained only by applying it in the context of enterprise processes that draw together, in an integrated and deliberate design, all relevant activities to achieve specific goals. Technology, particularly information technology, will enable logistic processes that are substantially different from the traditional ones. The Navy and the Marine Corps should use new technology to change the way logistics is accomplished, not simply to perform current tasks better.

The aging of the ships of the combat logistic force, the pending expiration of leases on the maritime prepositioning ships, and the need for a sea-based support platform for amphibious operations all present an opportunity to do careful examination and design of future logistic processes before major ship investments are made.

## RECOMMENDATIONS

The panel offers the following recommendations:

1. The Navy and Marine Corps should take the opportunity now, before starting the design of new logistic ships, to define and design future logistic processes, from the sources of materiel to its delivery in warfighter-ready condition to naval forces at sea, from the sea, and over the shore. Once the logistic processes are designed and the roles of logistic ships have been decided, the Navy should examine the desired characteristics of new logistic ships to see if they can be met by a common design, a modular design, or a design that is convertible to alternate roles.

2. The Navy and Marine Corps should learn how to exploit the advantages of standard shipping containers in supporting naval forces at sea, from the sea, and over the shore. Containers offer efficiency, control, and security in transporting and handling materiel. With emerging technology for load planning, content tagging, and shipment tracking, containers can be transformed from dumps of randomly stowed materiel to virtual supply depots of immediately accessible materiel that is warfighter ready.

3. The Navy and Marine Corps should develop and apply to logistic operations the emerging information technologies that promise to enable management of processes as integrated enterprises supporting naval operations:

- Automated marking and identification technology to eliminate manual input of critical logistic data;
- Sensors and intelligent software for monitoring logistic activities (e.g., shipments and maintenance) and for carrying out routine actions automatically;

- Displays and software for assimilating, presenting, and making easier to use the vast quantities of data;
- Modeling and simulation, for real-time planning, assessment, and selection of courses of action; and
- Distributed collaborative planning, for rapid coordination of resupply actions among the supplier, the transporter, and the user.

4. The Navy and Marine Corps should formulate and commit to a long-term plan—a path of evolution—to guide technology development, investment, and fleet implementation of a standard integrated, information-based process for maintaining weapon system readiness. The process should encompass the entire life cycle of a weapon system, from acquisition to disposal. The plan should give particular attention to current weapon systems, to infrastructure and common support needs, to integration of industry capabilities into the process, and to developing and exploiting the capabilities of the following technologies:

- Integrated digital weapon system databases;
- Computer-based technical training;
- Integrated maintenance information systems that tie together all information relevant to a technician's task and present it at the point of use in the most usable form;
- Sensor-based diagnostic and prognostic software; and
- Automated identification, tracking, and control of parts, supplies, and shipments.

# APPENDIXES

# A

# Terms of Reference

CHIEF OF NAVAL OPERATIONS

28 November 1995

Dear Dr. Alberts,

In 1986, at the request of this office, the Academy's Naval Studies Board undertook a study entitled "Implications of Advancing Technology for Naval Warfare in the Twenty-First Century." The Navy-21 report, as it came to be called, projected the impact of evolving technologies on naval warfare out to the year 2035, and has been of significant value to naval planning over the intervening years. However, as was generally agreed at the time, the Navy and Marine Corps would derive maximum benefit from a periodic comprehensive review of the implications of advancing technology on future Navy and Marine Corps capabilities. In other words, at intervals of about ten years, the findings should be adjusted for unanticipated changes in technology, naval strategy, or national security requirements. In view of the momentous changes that have since taken place, particularly with national security requirements in the aftermath of the Cold War, I request that the Naval Studies Board immediately undertake a major review and revision of the earlier Navy-21 findings.

The attached Terms of Reference, developed in consultation between my staff and the Chairman and Director of the Naval Studies Board, indicate those topics which I believe should receive special attention. If you agree to accept this request, I would appreciate the results of the effort in 18 months.

Sincerely,

J. M. BOORDA
Admiral, U.S. Navy

Dr. Bruce M. Alberts
President
National Academy of Sciences
2101 Constitution Avenue, N.W.
Washington, D.C. 20418



Enclosure

TERMS OF REFERENCE

TECHNOLOGY FOR THE FUTURE NAVY

The Navy-21 study (Implications of Advancing Technology for Naval Warfare in the Twenty-First Century), initiated in 1986 and published in 1988, projected the impact of technology on the form and capability of the Navy to the year 2035. In view of the fundamental national and international changes -- especially the Cold War's end -- that have occurred since 1988, it is timely to conduct a comprehensive review of the Navy-21 findings, and recast them, where needed, to reflect known and anticipated changes in the threat, naval missions, force levels, budget, manpower, as well as present or anticipated technical developments capable of providing cost effective leverage in an austere environment. Drawing upon its subsequent studies where appropriate, including the subpanel review in 1992 of the prior Navy-21 study, the Naval Studies Board is requested to undertake immediately a comprehensive review and update of its 1988 findings. In addition to identifying present and emerging technologies that relate to the full breadth of Navy and Marine Corps mission capabilities, specific attention also will be directed to reviewing and projecting developments and needs related to the following: (1) information warfare, electronic warfare, and the use of surveillance assets; (2) mine warfare and submarine warfare; (3) Navy and Marine Corps weaponry in the context of effectiveness on target; (4) issues in caring for and maximizing effectiveness of Navy and Marine Corps human resources. Specific attention should be directed, but not confined to, the following issues:

1. Recognizing the need to obtain maximum leverage from Navy and Marine Corps capital assets within existing and planned budgets, the review should place emphasis on surveying present and emerging technical opportunities to advance Navy and Marine Corps capabilities within these constraints. The review should include key military and civilian technologies that can affect Navy and Marine Corps future operations. This technical assessment should evaluate which science and technology research must be maintained in naval research laboratories as core requirements versus what research commercial industry can be relied upon to develop.

2. Information warfare, electronic warfare and the exploitation of surveillance assets, both through military and commercial developments, should receive special attention in the

review. The efforts should concentrate on information warfare, especially defensive measures that affordably provide the best capability.

3. Mine warfare and submarine warfare are two serious threats to future naval missions that can be anticipated with confidence, and should be treated accordingly in the review. This should include both new considerations, such as increased emphasis on shallow water operations, and current and future problems resident in projected worldwide undersea capability.

4. Technologies that may advance cruise and tactical ballistic missile defense and offensive capabilities beyond current system approaches should be examined. Counters to conventional, bacteriological, chemical and nuclear warheads should receive special attention.

5. The full range of Navy and Marine Corps weaponry should be reviewed in the light of new technologies to generate new and improved capabilities (for example, improved targeting and target recognition).

6. Navy and Marine Corps platforms, including propulsion systems, should be evaluated for suitability to future missions and operating environments. For example, compliance with environmental issues is becoming increasingly expensive for the naval service and affects operations. The review should take known issues into account, and anticipate those likely to affect the Navy and Marine Corps in the future.

7. In the future, Navy and Marine Corps personnel may be called upon to serve in non-traditional environments, and face new types of threats. Application of new technologies to the Navy's medical and health care delivery systems should be assessed with these factors, as well as joint and coalition operations, reduced force and manpower levels, and the adequacy of specialized training in mind.

8. Efficient and effective use of personnel will be of critical importance. The impact of new technologies on personnel issues, such as education and training, recruitment, retention and motivation, and the efficient marriage of personnel and machines should be addressed in the review. A review of past practices in education and training would provide a useful adjunct.

9. Housing, barracks, MWR facilities, commissaries, child care, etc. are all part of the Quality of Life (QOL) of naval personnel. The study should evaluate how technology can be used to enhance QOL and should define militarily meaningful measures of effectiveness (for example, the impact on Navy readiness).

10. The naval service is increasingly dependent upon modeling and simulation. The study should review the overall architecture of models and simulation in the DoD (DoN, JCS, and OSD), the ability of models to represent real world situations, and their merits as tools upon which to make technical and force composition decisions.

The study should take 18 months and produce a single-volume overview report supported by task group reports (published either separately or as a single volume). Task group reports should be published as soon as completed to facilitate incorporation into the DoN planning and programming process. An overview briefing also should be produced that summarizes the contents of the overview report, including the major findings, conclusions, and recommendations.

# B

# Study Contributors

The Panel on Logistics benefited from the briefings and discussions contributed by the following people:

Abraham, Phillip B., Office of Naval Research, *Current 6.2/6.3 Logistics Research*
Adams, Carl J., Boeing Defense & Space Group, *Joint Strike Fighter Logistics Impacts as Design Criteria*
Armstrong, Bonnie, Naval Supply Systems Command, *Total Asset Visibility*
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# Acronyms and Abbreviations

| | |
|---|---|
| AAAV | Advanced amphibious assault vehicle |
| AMIDD | Aviation Maintenance Integrated Diagnostics Demonstration |
| CNO | Chief of Naval Operations |
| COD | Carrier on-board delivery |
| CONUS | Continental United States |
| ICAS | Integrated Condition Assessment System |
| IMIS | Integrated Maintenance Information System |
| ISIS | Integrated Ship Information System |
| JSF | Joint Strike Fighter (program) |
| LCAC | Landing craft, air-cushioned |
| LOTS | Logistics over the shore |
| SBA | Simulation-based acquisition |
| TO | Technical order |
| TRAM | Transportable rearming method |
| VLS | Vertical launch system |